APPARATUS FOR REDUCING RETAINED MOISTURE CONTENT OF ARTICLES AND METHOD OF FABRICATING

[001] This invention was made with U.S. Government support through Government Contract Number DE-FC26-01NT41261 awarded by the Department of Energy, and, in accordance with the terms set forth in said contracts, the U.S. Government may have certain rights in the invention.

FIELD OF THE INVENTION

[002] This invention relates in general to clothes washing machines and more particularly to a clothes washing machine having apparatus for water extraction from clothes during spin cycles of the washing machine.

BACKGROUND OF THE INVENTION

[003] Conventional washing machines typically include a cabinet that houses an outer tub for containing wash and rinse water, a perforated clothes basket within the tub for holding articles such as clothes to be washed and an agitator disposed within the basket for agitating the clothes during a wash cycle. A drive and motor assembly for driving the agitator and the basket may be mounted underneath the outer tub. The motor is typically an AC induction motor, which can reverse its rotation direction to achieve different modes in a wash cycle. A pump assembly may pump water from the outer tub to a drain during a wash cycle. Conventional wash cycles will spin the basket at various times to extract water and wash fluids from clothes.

[004] Extracting water from clothes during spin cycles is desirable because it reduces the amount of energy required to dry the clothes after washing, such as in a conventional dryer. The energy efficiency rating of washers may include the energy required to dry clothes after washing. Spinning the wash basket is a common method of extracting water from clothes prior to the drying cycle. Using the mechanical energy of the spin cycle to extract water is more energy efficient than using the heat in a clothes dryer. More stringent

energy usage standards imposed on washing machines can require new and costly washer platforms. This is because efforts to increase water extraction have mainly been achieved through increased basket spin speed. This often requires more expensive drive systems that typically include costly motors and transmissions. Also, increased spin speed may result in problems with the high forces associated with possible out-of-balance conditions and the associated higher stresses in the basket.

[005] The retained moisture content (RMC) of clothes is a variable used to determine the amount of energy required to dry clothes after a wash cycle. Several factors affect clothing's RMC during a washing machine's spin cycle. These factors may include clothing material, clothing load, basket diameter, spin speed, spin duration, rinse temperature and chemical rinse agents.

BRIEF DESCRIPTION OF THE INVENTION

[006] A method of fabricating a wash basket for a washing machine is provided that may include providing a substantially cylindrical housing having a bottom and an inner wall, providing a plurality of geometric structures and connecting the plurality of geometric structures to the inner wall.

[007] A wash basket for a washing machine is provided that may include a housing having an inner wall fabricated by a first process and a plurality of geometric structures fabricated by a second process where the plurality of geometric structures are attached to and extend radially inwardly from the inner wall, the geometric structures comprising a separate structure relative to the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[008] FIG 1 is a perspective cutaway view of an exemplary washing machine.

[009] FIG. 2 is a front elevational schematic view of the washing machine shown in Figure 1.

[010] FIG. 3 is a schematic block diagram of a control system for the washing machine shown in Figures 1 and 2.

[011] FIG. 4 is a partial vertical cross sectional view of an exemplary wash basket for the washing machine shown in FIGS. 1 and 2.

[012] FIG. 5 is a partial horizontal cross section of the wash basket along line 5-5 shown in FIG. 4.

[013] FIG. 6 is a partial plan view of an exemplary configuration of ribs insertable into a wash basket in accordance with aspects of the invention.

[014] FIG. 7 is a plan view of an exemplary rib of FIG. 6.

[015] FIG. 8 is a side elevational schematic view of the washing machine of FIGS. 1 and 2.

DETAILED DESCRIPTION OF THE INVENTION

[016] FIG. 1 is a perspective view partially broken away of an exemplary washing machine 50 in which aspects of the present invention may be practiced. It is recognized, however, that the various benefits of the present invention may be demonstrated in other types of washing machines. The description of washing machine 50 below is therefore offered just for illustrative purposes, and in no way should be construed to limit application of the present invention in any aspect.

[017] Washing machine 50 includes a cabinet 52 and a cover 54. A backsplash 56 extends from cover 54, and a variety of appliance control input selectors 58, 60 may be mounted onto backsplash 56. Input selectors 58, 60 comprise a user interface for operator selection of operational machine cycles and modes of operation. A lid 62 is mounted to cover 54 and may be movable between an open position facilitating access to a wash tub 64 located within cabinet 52, and a closed position forming a covered enclosure over wash tub 64.

[018] Tub 64 includes a bottom wall 66 and a sidewall 68, and a basket 70 may be rotatably mounted within washtub 64. An agitator, impeller, or oscillatory basket mechanism 116 (shown in FIG. 2) may be disposed in basket 70 to agitate the articles and liquid in basket 70. The agitator 116 and/or wash basket 70 may be positioned to rotate or otherwise have motion, e.g., oscillatory or wobbling motion, about an axis, such as a vertical axis, an axis with some degree of tilt or a horizontal axis. Such an oscillatory mechanism 116 is not necessary to implement embodiments of the invention.

[019] FIG. 2 is a view of washing machine 50 including wash basket 70 movably disposed and rotatably mounted in washtub 64 in a spaced apart relationship from tub side wall 64 and tub bottom 66. Wash basket 70 may include a plurality of perforations therein to facilitate fluid communication between an interior 100 of wash basket 70 and washtub 64. A dispenser (not shown in FIG. 2) may be provided to produce a wash solution by mixing fresh water with a detergent or other composition for cleansing of articles in wash basket 70. The agitator, impeller, or oscillatory basket mechanism 116 may be disposed in wash basket 70 to impart an oscillatory motion to articles and liquid in wash basket 70. As illustrated in FIG. 2, agitator 116 is exemplarily oriented to rotate about a vertical axis. It will be appreciated, however, that various embodiments of the present invention may be used with horizontal axis washing machines as well. Wash basket 70 and agitator 116 may be driven by motor 120 through a transmission and clutch system 122. Clutch system 122 facilitates driving engagement of wash basket 70 and agitator 116 for rotatable movement within washtub 64. The clutch system 122 facilitates relative rotation of wash basket 70 and agitator 116 for selected portions of wash cycles. Motor 120, transmission and clutch system 122 may form a multiple speed drive that is capable of spinning wash basket 70 at multiple speeds to accomplish different objectives at different points in the wash cycle.

[020] Operation of machine 50 may be controlled by a controller 138, which is operatively coupled to the user interface input located on washing machine

backsplash 56 (shown in FIG. 1) for user manipulation to select washing machine cycles and features. In response to user manipulation of the user interface input, controller 138 operates the various components of machine 50 to execute selected machine cycles and features. For example, clothes are loaded into wash basket 70, and washing operation is initiated through operator manipulation of control input selectors 60 (shown in FIG. 1). Tub 64 is filled with water and mixed with detergent to form a wash fluid then wash basket 70 is agitated with agitator 116 for cleansing of clothes in wash basket 70. After a predetermined period of wash action, tub 64 is drained and wash basket 70 is spun to extract wash fluid from the clothes. Clothes are then rinsed with fresh water and wash basket 70 is spun again to remove water from clothes. Depending on the particular wash cycle selected, multiple wash and spin portions of the wash cycle may be executed.

[021] FIG. 3 is a schematic block diagram of an exemplary washing machine control system 150 for use with washing machine 50. Control system 150 includes controller 138, which may, for example, be a microcomputer 140 coupled to a user interface input 141. An operator may enter instructions or select desired washing machine cycles and features via user interface input 141, such as through input selectors 60 (shown in FIG. 1). A display or indicator 144 coupled to microcomputer 140 displays appropriate messages and/or indicators, such as a timer, and other known items of interest to washing machine users. A memory 142 is also coupled to microcomputer 140 and stores instructions, calibration constants, and other information as required to satisfactorily complete a selected wash cycle.

[022] Power to control system 150 is supplied to controller 138 by a power supply 146 configured to be coupled to a power line L. Analog to digital and digital to analog converters (not shown) are coupled to controller 138 to implement controller inputs and executable instructions to generate controller output to washing machine components such as those described above in relation to FIGS. 1 and 2. More specifically, controller 138 may be operatively

coupled to motor 120, clutch system 122, drive system 148, brake system 151, water valves 152 and drain pump/drain valve 154 as well as other components of machine 50 according to known methods. Water valves of machine 50 (not shown) may be in flow communication with a dispenser 153 (shown in phantom in FIG. 3) so that water may be mixed with detergent or other composition of benefit to washing of garments in wash basket 70.

[023] In response to manipulation of user interface input 141 controller 138 monitors various operational factors of washing machine 50 with one or more sensors or transducers 156 and executes operator selected functions and features according to known methods. While an electronic controller 138 is described and illustrated in FIG. 3, it is contemplated that known electromechanical control mechanisms may be employed in alternative embodiments.

[024] The retained moisture content (RMC) of clothes after the final spin cycle may be defined as:

$$RMC = \frac{(wet\ weight\ of\ clothes - dry\ weight\ of\ clothes)}{dry\ weight\ of\ clothes} \times 100$$

Reducing or lowering the RMC after final spin will reduce the amount of dryer energy needed to dry the clothes. Shorter drying cycles may also be obtained thereby synchronizing the length of a drying cycle with that of a wash cycle. This enables a user to do laundry more efficiently (drying cycles are typically longer that wash cycles thereby creating a bottleneck when transitioning loads from the washing machine to the dryer). Reducing RMC also allows for more efficient rinsing of clothes. A wash cycle separates soil from clothes and a rinse cycle rinses the loosened soil from the load to avoid deposition on other areas of the clothes. It has been shown through testing that a 20% reduction in RMC over three rinsing cycles (typical in a household washing machine) may reduce the amount of suspended, non-adsorbed particles in the wash

solution by 50%. More efficient rinsing produces cleaner clothes after washing.

[025] One aspect of the invention allows for a plurality of geometric structures 159, such as ribs 160, to be formed on the periphery of inner wall 162 of wash basket 70 as shown in FIGS. 2 and 4. It has been found that such structures 159 may reduce RMC as a function of at least the structures' height, spacing from one another and geometry. With respect to ribs 160, it will be appreciated that ribs 160 may be orientated vertically or circumferentially relative to inner wall 162, or at any angle between vertical and circumferential. Ribs 160 increase the local force per area, or provide discrete pressure points on clothing during a spin cycle. This compresses the clothing thereby squeezing clothing fibers and decreasing the size of local capillaries, which increases the local wicking action towards ribs 160 due to the capillary action within the clothing. This increases the amount of water extracted from the clothing during the spin cycle. It will be appreciated that various embodiments of the invention may be formed as part of an injection molding process for fabricating a wash basket 70.

[026] Ribs 160 may be shaped or formed in various ways other than being linear members. Embodiments of ribs 160 may include curves, waves or other combinations of geometric shapes. Embodiments of other geometric structures 159, such as a plurality of protrusions or protuberances, are not limited to being continuous members and may also be formed as dimples or nubs extending from the inner wall 162 of wash basket 70. Various embodiments of the invention allow for flexibility during manufacture.

[027] Another aspect allows for various embodiments of geometric structures 159 to be formed independently of or as a separate structure from wash basket 70. As a separate structure the geometric structures 159 may then be attached to the wash basket as illustrated in FIG. 6. Exemplary embodiments of structures 159, such as ribs 160, may be formed as a unitary

piece or as individual ribs that may be attached to the inner wall 162 of wash basket 70. In an embodiment, wash basket 70 and/or structures 159 may be stainless steel, it being appreciated that basket 70 and attachable structures 159 may be fabricated of various compositions. In this respect, it has proved difficult to fabricate stainless steel wash baskets with integral structures 159, such as ribs 160, as a unitary product without compromising the basket's structural integrity.

[028] One aspect allows for wash basket 70 to be fabricated of various materials such as stainless steel, plastic or porcelain steel, for example, or wash basket 70 may be enameled. Wash basket 70 may be configured to have attached thereto a secondary geometry or geometric structure 159 shown in FIG. 2. Geometric structures 159, which may be ribs 160, promote improved washing of, and/or water extraction from, articles being washed. Further, because the secondary geometry 159 may be a separate structure and attachable to the inside of wash basket 70, the structural integrity of the basket is not compromised in any respect. The secondary geometry 159 may be fabricated of various materials and combinations thereof such as synthetics, thermoplastic, plastic, synthetic resins, ceramics, steel and/or stainless steel, it being appreciated that other materials and combinations thereof will be recognized by those skilled in the art of fabricating wash basket 70 and the secondary geometric structure 159.

[029] The secondary geometry 159 may be formed as elongated ribs 160 or semi-spherical protrusions, for example. It will be recognized that embodiments of the attachable secondary geometry 159 may assume a wide range of geometries provided they are suitably attachable to the inside of wash basket 70. The secondary geometry 159 may be attached to the inner wall 162 of wash basket 70 by various attaching means such as screws, snaps, bolting, adhesives, spot or ultrasonic welding, or interlocking joints, for example. Other attaching means will be recognized by those skilled in the art. The secondary geometry 159 may be rigidly attached to the inner wall 162 so

it does not move relative to the wash basket 70 thereby functioning in cooperation with the basket during wash and spin cycles. In this respect, during a wash cycle the clothes within wash basket 70 will impinge or rub against the secondary geometry 159 thereby promoting mechanical cleaning of the clothes, much in the same way an agitator does in a vertical axis washing machine. During a spin cycle, the secondary geometry 159, such as ribs 160, cause stress concentrations in clothes under spin at points where the clothes contact the secondary geometry 159. This promotes a local wicking and/or ringing action in clothes that causes more moisture to be removed from the clothes thereby reducing the RMC.

[030] One aspect of the invention allows for ribs 160 to extend vertically from the bottom 164 of wash basket 70 a distance that is less than the height of the inner wall 162 of wash basket 70. It has been found that this configuration enhances the wicking action of the clothing to reduce RMC while maximizing the volume of water contained in the washtub 64. This may allow for an improved energy rating of the washing machine 50. An exemplary standard for energy standard compliance is the Modified Energy Factor (MEF), which may be defined as:

$$MEF = \frac{washer\ basket\ volume}{hot\ water\ energy + mechanical\ energy + dryer\ energy}$$

[031] Dryer energy is typically greater than that of a washing machine, such as machine 50, so reducing dryer energy may have a significant effect of the MEF. In this respect, one way to reduce dryer energy is to extract more water from the clothes during the final spin cycle. Sizing ribs 160 so they extend a distance less then the height of wash basket 70 allows for a reduction in RMC while maximizing the volume of the washer basket.

[032] Ribs 160 may have a constant cross section. This may inhibit clothes from moving to the top of wash basket 70 during spin. A plurality of ribs 160 may be disposed around the entire circumference of the wash basket 70 that

extend substantially perpendicularly from the bottom 164 of the wash basket 70 to approximately the midpoint of the basket's height, for example. The cross section of ribs 160 may be a constant semi-circular cross section, as shown in FIG. 5, or other geometrical cross-sections. Ribs 160 may be tapered and in one embodiment the lower portion of the ribs 160 may extend further away from the inner wall 162 of wash basket 70 than the upper portions of ribs 160. Tapering ribs 160 may increase the volume of water that may be contained in washtub 64 thereby improving the energy rating of washing machine 50. In one aspect, the length, spacing and cross section dimensions of ribs 160, or other geometric structures 159, may be optimized to maximize the reduction in RMC and water volume in washtub 64 for that machine. This optimization may be based at least in part on the operational characteristics or parametrics of a washing machine. These may include wash basket diameter, volume, spin rate and duration of spin, load size, water temperature and clothing composition, for example. Other factors will be recognized by those skilled in the art.

[033] Ribs 160 may extend radially inwardly toward the center of basket 70 with a constant radius of curvature measured from the inner basket wall 162. The radius of curvature may vary and in one aspect may be greater than about 0.25 inches and less than about 1.00 inch. In an exemplary embodiment the radius of curvature may range between about 0.25 and 0.625 inches. Alternate embodiments allow for the radius of curvature to be less than 0.25 inches or greater than 1.00 inch as a function of the type of articles under spin, and various operating parameters and performance requirements of machine 50, for example. Ribs 160 may be circumferentially spaced apart varying distances, and in an embodiment may be spaced apart approximately 1.25 inches between longitudinal centerlines. In alternate exemplary embodiments ribs 160 may have a constant cross section formed with a varying radius of curvature.

[034] An exemplary embodiment of attachable geometric structures 159, such as attachable ribs 160, shown in FIG. 6, allows for a cross section of ribs 160 to be formed substantially as a bell-shaped curve with concave portions 163 that transition ribs 160 to integrate with the inner wall 162 of the wash basket 70. Other curvatures will be recognized by those skilled in the art. In an embodiment, the distance from the inner wall 162 of the wash basket 70 to proximate the apex of a rib 160 extending radially toward the center of the basket may be between about 0.25 inches and 1.00 inch. Alternate embodiments allow for the attachable geometric structures 159 to be protrusions, dimples, waveforms or other shapes. Heights of the geometric structures 159 may extend away from the inner wall 162 of wash basket 70 varying distances.

[035] Geometric structures 159, such as ribs 160, may comprise a flexible or resilient material so that they conform to the surface of inner wall 162 of wash basket 70 when attached. The portions of structures 159 that interface with inner wall 162 may be manufactured using a spring or biasing feature for conformance with inner wall 162. Insert or rotary molding, for example, may be used to manufacture geometric structure 159 with a spring or biasing feature. Alternate embodiments may use an interface material that may be bonded to structures 159 so it is positioned between the structures and inner wall 162 when they are attached. These aspects allow for larger tolerances in manufacturing both wash basket 70 and geometric structures 159, such as ribs 160, which may lower production costs and allow for a tight interface so that clothes are not caught in the interface area.

[036] Further, it has been determined that for a given spacing of ribs 160, which may be measured between centerlines, the width W and angle Θ may be optimized to increase a pressure component F_A proximate the top or apex of ribs 160 during spin. During a spin cycle of machine 50, clothes may impinge the surface of ribs 160 at various points. Referencing FIG. 7, portions of clothes may impinge the top of ribs 160 and portions of clothes

may drape over a rib 160 impinging one or both sides of the rib, such as along concave portion 163. In this respect, portions of clothes may impinge and extend along each side of ribs 160, to varying distances, toward inner wall 162 of basket 70. When this occurs, width W and angle Θ may be optimized to increase pressure component F_A, which increases the local wicking action proximate the top of a respective rib 160. Increasing angle Θ will correspondingly increase force component F_T, which causes the portions of clothes draped over rib 160 to "pull" toward inner wall 162. This pulls corresponding portions of clothes against the top of rib 160 thereby increasing the local wicking action.

[037] If ribs 160 are sufficiently spaced apart, portions of clothes may impinge inner wall 162 between ribs 160. This reduces force component F_T relative to a force component resulting from portions of clothes not impinging inner wall 162. In an exemplary embodiment, ribs 160 are sufficiently spaced apart so that portions of clothes only impinge ribs 160 proximate their respective tops. It has been determined that the local wicking action proximate the top of the ribs 160 is maximized if portions of clothes do not impinge or only slightly impinge a ribs' sidewalls. Alternate embodiments allow for ribs 160 to be sufficiently spaced apart so that clothes impinge a portion of a rib's sidewall but not the inner wall 162 of wash basket 70. Spacing of ribs 160, and the optimization of width W and angle Θ for a given spacing, may be optimized based on the operational characteristics and parametrics of a washing machine 50.

[038] An embodiment allows for ribs 160 to have a textured or rough surface area to create sufficient friction between ribs 160 and clothes in wash basket 70 to hold the clothes in place against ribs 160. This allows for ensuring that the clothes positioned between adjacent ribs 160 are suspended away from the inner wall 162 of the wash basket 70 during spin. Suspending clothes increases the pressure or force exerted against the clothes along the surface of ribs 160 impinging the clothes during spin, such as proximate the

top of individual ribs, relative to the exerted pressure if the portions of clothes positioned between ribs 160 rested against the inner wall 162 during spin. The texturing also effectively decreases the wetting angle allowing more water to move away from clothing more easily during spin.

[039] One aspect of the invention allows for the geometric structures 159, such as ribs 160, to be formed entirely or partially of a porous material to enhance the wicking action at the surface of the structure 159. This is due to small porous apertures formed in structures 159. Various porous materials may be used to form structures 159 including ceramic, metal, plastic, and fabric materials, for example. It will be appreciated that other materials known to those skilled in the art may be used. Another aspect allows for a porous material 165 (as illustrated in FIG. 5) to be formed over all or a combination of ribs 160, or other structures 159, to achieve a similar enhancement to the wicking action proximate a rib surface. The material may be placed over solid or porous ribs 160, either of which may be hollow. In an embodiment a commercially available fabric known as CoolMax, manufactured by Dupont, may be used to cover a combination of ribs vertically and circumferentially. This fabric or wicking material enhances the wicking effect of ribs 160. Exemplary embodiments of geometric structures 159 that are hollow may have apertures formed therein for draining water, which prevents mildew and detergent build-up.

[040] In one aspect of the invention a means for supplying or introducing air to the wash basket is provided. This allows for air to flow onto clothes in the wash basket 70 during spin for enhancing evaporation of water from the clothes thereby reducing the RMC. One aspect allows for air to flow internal to porous ribs 160, or other structures 159, to enhance the evaporative effect proximate the surface of the ribs. With reference to FIG. 8, in an embodiment the means for introducing air may include an aperture 170 formed in cabinet 52, such as in the cabinet's back panel 172, for example. Aperture 170 may be formed in other parts of cabinet 52, lid 62 or other parts of machine 50.

Aperture 170 may be an appropriately sized vent that allows air to be drawn into the cabinet 52 by the spinning of the wash basket 70, which effectively functions as a centrifugal pump during spin.

[041] The means for introducing air may include a duct 174 that directs airflow from aperture 170 to an outlet port 176, which in an embodiment may be coaxial with an agitator 116 when lid 62 is closed. This allows for air to be drawn down the agitator shaft into wash basket 70 and circulate up the basket inner wall and over clothes during spin. It is expected that some air will flow out of the cabinet 52 after flowing up the inner walls. A heating device 178 may be provided for heating air flowing through duct 174, and a device 180 for moving air, such as a commercially available blower, may be provided for pushing or pulling air into duct 174. In an embodiment, duct 174 may be integral with lid 62. It will be appreciated that duct 174, heating device 178 and the device 180 may be used in various combinations and located in various places within washing machine 50.

[042] An alternate embodiment allows for a blower, such as device 180, to be located for pulling saturated air out of the wash basket 70 during spin so that less humid air may be drawn or pushed into the wash basket. This allows for metering air into and/or out of the wash basket 70 during spin so air with relatively low humidity is continuously introduced into the wash basket 70 to enhance the evaporation of water from clothes being spun. Air may be metered into and/or out of wash basket 70 at a constant flow rate or a pulsating rate, for example, to account for operating parameters or characteristics of machine 50 and environmental factors such as the relative humidity of ambient air.

[043] Alternate embodiments allow for a removable or permanently affixed device (not shown) to attach to an upper rim of wash basket 70, or other appropriate mounting location such as the balance ring, for directing air onto clothes during spin. The device may be substantially rectangular while conforming to the basket's curvature, for example, and include an inlet port

that directs air into the device during spin. The device may be configured to direct the air entering the inlet port downwardly toward clothes being spun in the basket. The speed of the spinning basket forces air through the inlet port to flow over the clothes.

[044] While the exemplary embodiments of the present invention have been shown and described by way of example only, numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.